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BURNING TRIAL ON SCHEDULE IV CONTAINER

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BURNING TRIAL ON SCHEDULE IV CONTAINER

by

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ABSTRACT

A Schedule IV container that had been in use for about two years, was loaded with approximately 1200 electric detonators and subjected to a fire test. The fire temperature was maintained at about 1000°C and the test was run for one hour. The detonators began exploding twenty-five minutes after the start of the burn and continued with the last detonator exploding at a time of forty minutes.

KEYWORDS: Schedule IV container, explosive magazine, Burn Test, electric detonators

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ESSAI DE COMBUSTION RÉALISÉ DANS LE RÉCIPIENT D'ESSAI IV

par

E. Contestabile*, R.R. Vandebeek**, et R.A. Augsten^

RÉSUMÉ

Un récipient d'essai utilisé depuis deux ans a été chargé avec environ 1 200 détonateurs électriques et soumis à un essai du point de feu. La température du feu a été maintenue à environ 1 000°C au cours de l'essai d'une durée d'une heure. Les détonateurs ont commencé à exploser 25 minutes après la mise à feu, et ont continué à faire explosion jusqu'au dernier après 40 minutes.

MOTS-CLÉS: Récipient d'essai IV, dépôt d'explosifs, essais de combustion, détonateurs électriques.

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THE SCHEDULE IV CONTAINER

INTRODUCTION

The Schedule IV container tested was cubical in shape, having 120 cm long sides and constructed along the guidelines given in the Explosives Act (1986). Information from the manufacturer indicated that the laminated construction, from the outside to the inside, consisted of 12.5 mm fir plywood, 3 mm (11 gauge) mild steel, 25.4 mm rigid glass fibre insulation (Fiberglass AF-545, RSI = 0.72), and 12.5 mm fir plywood. The door was of the same construction, with the steel laminated overlappingthe container opening by 2.5 cm. Three welded hinges secured the door on the right, and a metal clasp on the left provided for a padlock closure. Observations and comments made on the container tested are reproduced in Appendix I.

EXPERIMENTAL SET-UP

A 1.6 cm diameter hole was drilled in the centre of the top panel of the container to allow for the installation of the thermocouples. Thermocouple TC-1 was mounted outside the container, in the centre of the bottom panel and it recorded the fire temperature. Eleven other, stainless steel clad, thermocouples were positioned in the container as indicated below.

TC-1 - Adjacent to container bottom (centre) in fire
TC-2 - Bottom panel, centre
TC-3 - Suspended in centre of container
TC-4 - Top panel, centre
TC-5 - Door, bottom, left corner
TC-6 - Door, upper, left corner
TC-13 - Bottom panel, left, front corner
TC-14 - Bottom panel, left, back corner
TC-15 - Bottom panel, right, back corner
TC-16 - Bottom panel, right, front corner
TC-17 - Top panel, left, front corner
TC-18 - Back panel, centre, 10 cm from top panel, in contact with exposed metal screw.

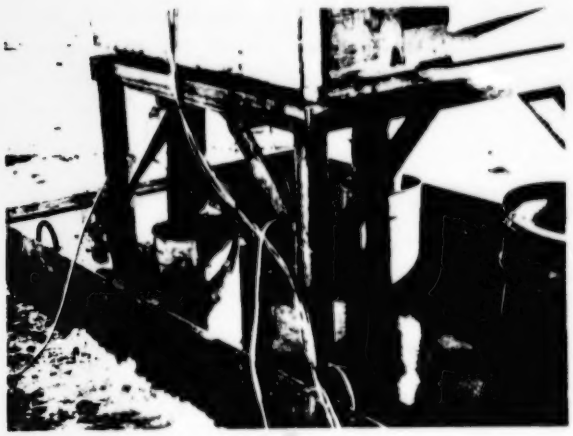
Figure 1 shows a bundle of thermocouples, with TC-2 terminating on the centre of the bottom panel, TC-5 and TC-6 leading to the door opening and TC-13, TC-14, TC-15 and TC-16 radiating to the bottom four corners.

1. Thermocouples on bottom panel of container

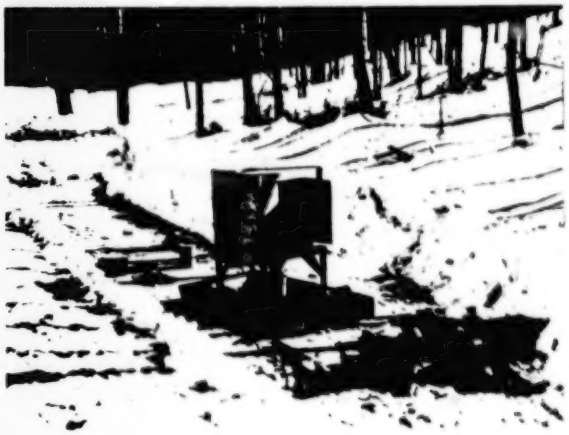
As shown in Fig. 2, the Schedule IV container was placed on a steel stand, to provide an area for the combustion material. The following items can also be seen in this figure.

(a) On the left, the bundle of thermocouples is guided down the leg of the stand.
(b) A steel pan was used to contain the fire and fuel oil.
(c) Two, 20 l containers, filled with fuel oil and logs as wicks, were placed under the stand toward the back.
(d) A 70 l drum of fuel oil with a fitted lid was placed in the pan in front of the container door.
(e) Two copper tubes, used to feed fuel oil, can be seen on the left.

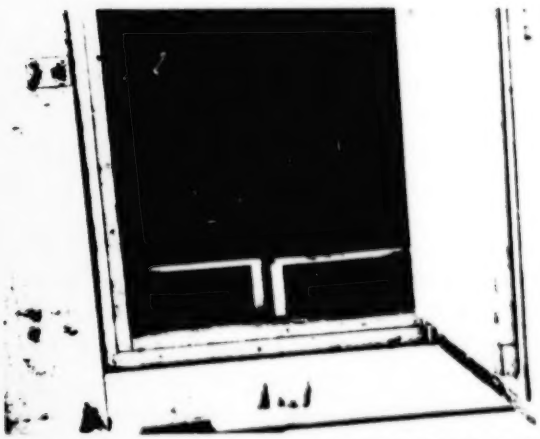
Figure 3 shows the container at the test site before it was loaded and before the wood was piled around it. Figure 4 is a view through the door opening showing the location of the five cases of electric detonators on the floor of the container. The five cases were comprised of three containing seismic, one short delay and one Magnadets, for a total of about 1200 detonators.



2. Container on steel stand
(For other details refer to text)



3. Container in test area



4. Box of electric detonators as placed in the container

OBSERVATIONS AND DISCUSSION

The burn test was recorded with a video camera and the temperatures were monitored with a multi-channel recorder. Once the fire was ignited, the fuel oil was pumped at about 4 l per minute. During the one hour test, the ambient temperature ranged from 930 to 1060°C.

Once loaded, the door was held shut with a metal rod and wire. A cord of hardwood was then piled underneath the stand and all around the container as indicated by Fig. 5.

5. Container ready for testing

The following list indicates major observations that were made on reviewing the video-tape. Some of these events caused a corresponding effect on the recorded temperature profiles.

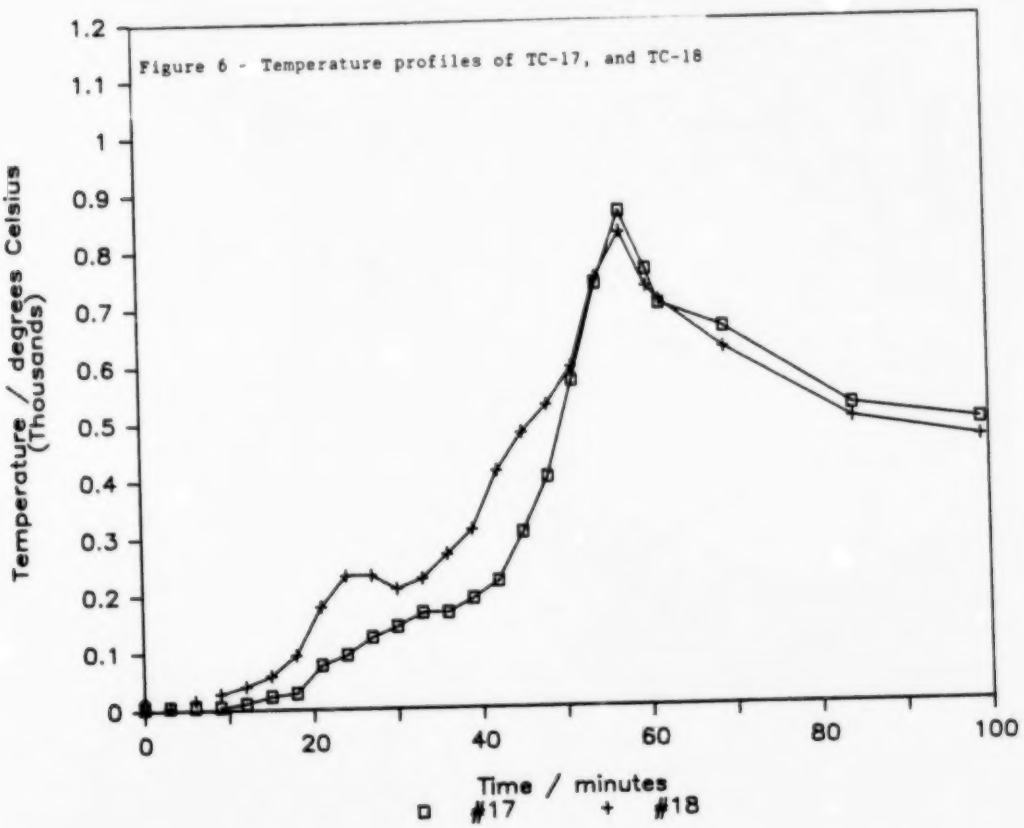
Fire Temperature:

3:00	TC-1 - 480°C
6:00	TC-1 - 804°C
8:00	TC-1 - 930°C
8:30	Tall flames on back side of container (two pails of fuel burning)
13:00	Jetting from 70 l fuel drum begins (front, right)
16:00	Violent burning (front, right) continues to 22 min
18:15	Violent jetting to right and back
18:42	Container door vents (opens and closes)

19:00 Outside wood laminate well charred
19:30 Flames completely engulfing container
20:00 Charred wood laminate dropping from container
21:00 Violent burning in front of container
22:10 70 l container vented violently
23:00 Exterior wood laminate almost completely burned
Smoke emanating from door (lock side)
25:30 First detonator fired
26:00 Flames emanating from door (lock side)
26:08 Second detonator fired
26:20 Detonators firing individually
28:40 Flames emanating from perimeter of door
29:00 Multiple detonators firing
29:30 Flames jetting from door (lock side)
30:30 Flames emanating from bottom and lock side of door. Detonators firing individually
31:30 Flames jetting from door
33:00 Fire subsides, violent flames emanate from within container (all around the door), to 40:00 min
36:20 Rapid firing of detonators to 38:30 min
38:30 Detonators firing individually
39:57 Last detonator fired
40:00 Upper part of door warped
41:00 Large flames emanating from warped area of door
52:00 Flames from within container subside
54:00 Flames from within, totally contained
60:00 Test considered completed

Some of the events indicated above can be correlated to the temperature records. The temperature records indicated that the fire oscillated about the temperature of 1000°C for the one hour duration of the test. Other observations made are listed below.

Figure 6 - Temperature profiles of TC-17, and TC-18

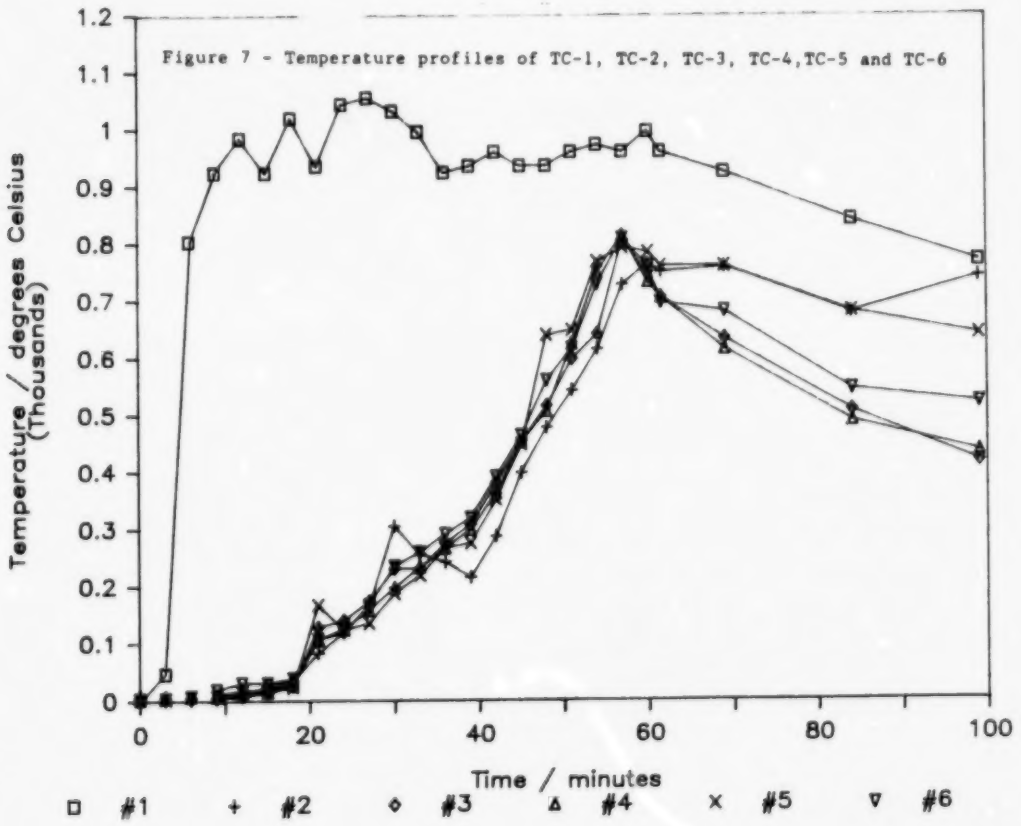


(a) The burning of the fuel in the pails that caused the tall flames at the back side of the container, coupled with the high thermal conductivity of the metal screw, resulted in TC-18 to register a quick rise in temperature. As comparison, note the difference between the TC-17 and TC-18 traces shown in Fig. 6. TC-18 detected much higher temperatures than the other thermocouples until the detonators began to fire at t = 25.5 minutes. The sensed temperature then dropped and followed the trend of most of the other thermocouples.

(b) As seen from Fig. 7, most of the thermocouples, especially TC-3, TC-4, and TC-5, showed a fast rise and sudden fall or decrease in the rate of temperature rise a t = 20 min. It is believed that the thermocouples were responding to a temperature rise due to water being evaporated. The steam was contained for a short time during which there was a sharp rise in temperature and then released at about t = 19 min. causing the temperature drop. The source of steam was snow an ice that had adhered to the cartons containing the detonators.

(c) All the thermocouples on the bottom panel (TC-2, TC-13, TC-14, TC-15, and TC-16), began registering much higher temperatures than the rest when the detonators started firing (t = 25.5 min). These results are shown in Fig. 8. As expected, the perimeter thermocouples registered the highest rates the detonators destroying the inside wooden liner and insulation as they fired. The temperature profile of TC-13 indicates that the bottom, front, left corner sustained the most damage. TC-13 quickly rose to the fire temperature and remained there for at least ten minutes. It then decreased, (t=50 min)

Figure 7 - Temperature profiles of TC-1, TC-2, TC-3, TC-4,TC-5 and TC-6



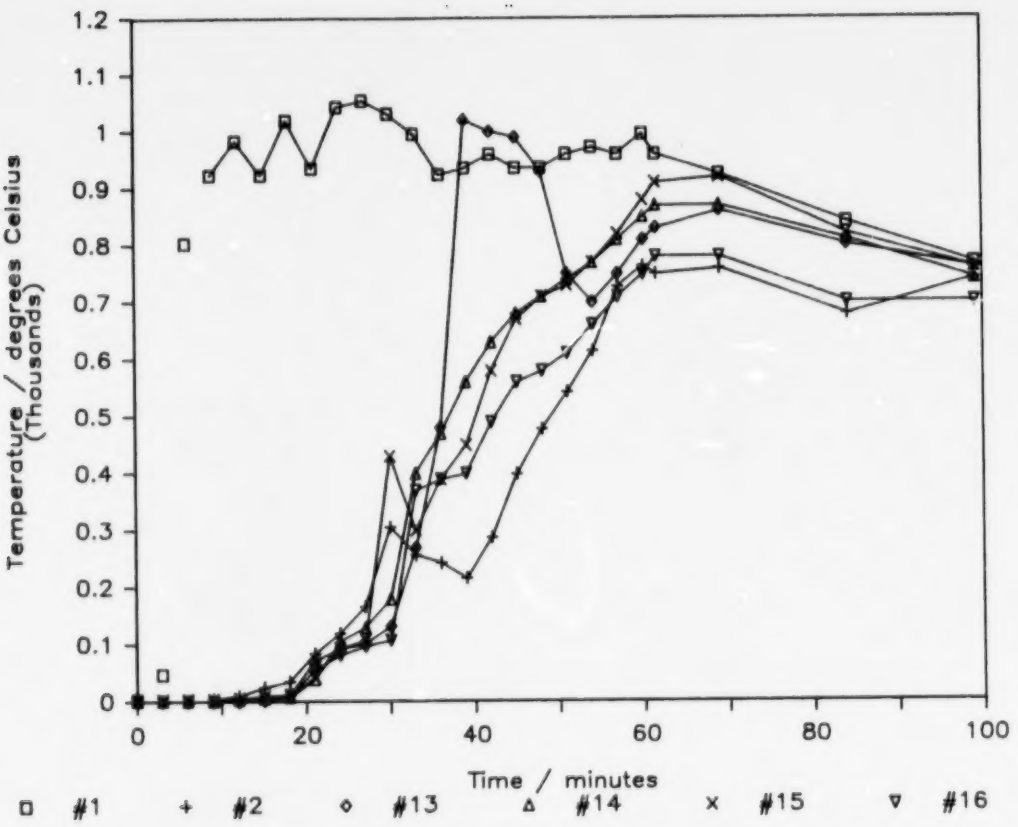


Figure 8 - Temperature profiles of TC-1, TC-2, TC-13, TC-14,TC-15, and TC-16

probably, due to the insulating effect of the ashes and insulation falling from the top panel. The remaining thermocouples kept measuring temperatures that would eventually approach that of the fire.

(d) The other thermocouples (TC-3, TC-4, TC-5, TC-6, TC-17 and TC-18) began indicating sharp rises in temperature when flames were seen emanating from the perimeter of the door at t=26 min. (Refer to Fig. 9.) This trend continued to about 58 min when maximum temperatures were recorded. After this time, the registered temperatures kept falling.

Observations after the burn indicated that the metal container had maintained its integrity as indicated by Fig. 10. The door, as seen from Fig. 11, was warped on the clasp side, but otherwise held. Figure 12 shows the right hand side.

Close inspection revealed a 3 cm crack on the bottom, front, left corner. The bottom panel had many bulges and several perforations. Figures 13 and 14 indicate the condition of the insulation.

RECOMMENDATIONS

This type of container can be greatly improved at little cost by using insulation rated for higher temperatures. The AF 545 insulation presently used has a binder and glass fibre that melt at about 150°C to 1000°C respectively. It is possible to use mineral fibre or alumina/silica insulation that is rated from 1300°C to 1600°C (1).

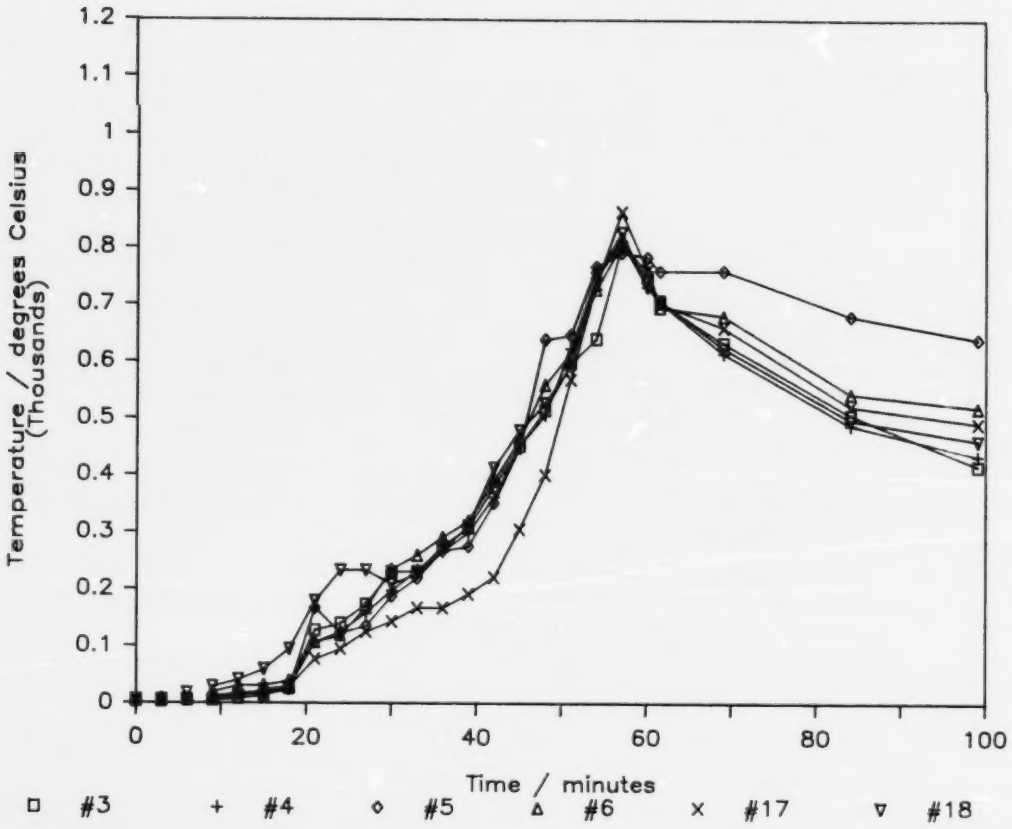


Figure 9 - Temperature profiles of TC-3, TC-4, TC-5, TC-6, TC-17 and TC-18

Figure 10 - Container after burn

Figure 11 - Heat caused door to warp

Figure 12 - Right side of container after burn

Figure 13 - Substantial deterioration of insulation

Improving insulation should increase the time to the first detonator firing. However, since the presently-used inner wooden liner and insulation are easily damaged as the detonators fire, as indicated by the extensive damage to the bottom panel, a substitute liner material should be considered. A material such as steel, in the existing design, would reduce the insulating value, however, if it were coupled with the higher rated insulation, this would not occur. Steel would protect the insulation and result in an increase in the time required to function all the detonators.

A weakness in most containers is usually the door and opening. Structurally the existing

Figure 14 - Deterioration of insulation (back, left corner)

closure can be improved by forming a lip on the perimeter of the door and opening and by providing two clasps for the locking mechansim. The insulating value around this opening can then simply be improved by incorporating an insulating tape similar in material to those mentioned above.

ACKNOWLEDGEMENTS

The authors acknowledge the extensive effort of D. Wilson, in cooperation with E. Sickman and C. Carriere of the Technical Service Division, to coordinate the acuisition and transportation of supplies and equipment to the site and D. Cox for assisting in the preparation of the test.

REFERENCES

1. Kaowool, Ceramic Fiber Products, Babcock & Wilcox, 2102 Old Savannah Rd. Augusta, Georgia, USA, 30903.
2. Thermofab, Albion Industrial Products, 2195 Ekers Ave., Montreal, Quebec, Canada, H3S 1C7.

APPENDIX I

This is a note to FIle 5035-1 by L.B. Buchanan, January 30, 1987.

The Schedule IV Container (120cm x 120cm x 120cm) obtained from Boyes Explosives and to be tested at CERL was examined. It is, I would say, typical of the Boyes containers insofar as general workmanship and tightness of the door is concerned.

However, it does not appear to be of their original design which I understood was the one to be tested. Rather, it appears to be to their new design (drawing on file). For example, a nominal 2.54cm x 2.54cm wood strip is around the door frame and around the insulation on the inside of the door, whereas on the original design the wood was replaced with the 2.54cm x 2.54cm metal channel. The steel plate in the walls adjacent to the door opening, extends into the opening about 1.9cm to provide a door stop.

Further, screws are used to secure the inner plywood. They appear to be on 40cm centers and spaced about 25cm apart. Their heads are counter-sunk in the plywood with plastic wood covering. However, for a few, plastic wood has fallen out exposing the metal head.

The inner plywood on the door appears to be only 0.64cm, not 1.27cm, and the thickness of the laminate on the inside of the door indicates that the thickness of the Fiberglas insulation is not 2.54cm, only at most 2.22cm.

The door is hung by three hinges, not the continuous hinge used on earlier models.

The door does not have the original mortise lock type lock but is secured by hasps. When a bolt is inserted into the latter with the door shut there is a little play, about 1.5mm to 3mm.

When closed, there appears to be a gap between the inner lining of the door and adjacent inner lining of the box (about 6.4mm at the lock side and at the bottom, and only about 1.5mm at the top).

Inner walls have the required plaques but no provision for exterior removable Detonator sign.

Box has two 10cm x 10cm wooden skids beneath, parallel to the front and rear walls.

Later, at Osgoode, Bob Davis, Boyes confirmed that the container has been built to their new design, i.e. without channel in the corners etc. It has been in use for about a year. The truck on which it was mounted would make about two trips a week at maybe 160km per trip, so the container has gone about 16000 road kilometers.

When queried about the plywood thickness, Bob agreed it looked thinner than 1.27 cm, but claimed it is what is sold as 1/2 inches nowadays. The Fiberglas insulation he says is AF 545 and full 2.54cm thick and the package so says.